Claims

1. A crystal-controlled oscillator, the crystal being formed from a material that is suitable for use in the oscillator, characterised in that the thermal expansion characteristic of the material itself enables temperature dependence of the oscillator frequency to be controlled over an operating temperature range for the oscillator.

2. A timing device incorporating the crystal-controlled oscillator of claim 1.

3. An oscillator as claimed in claim 1 or 2 wherein the thermal expansion characteristic is anisotropic or isotropic.

4. An oscillator as claimed in any one of the preceding claims wherein the thermal expansion characteristic of the material is adapted by tuning the coefficient of thermal expansion of the material.

5. An oscillator as claimed in claim 4 wherein tuning is achieved by:
(1) modifying the composition of the crystal; and/or
(2) cutting the material along a direction that has zero or near zero thermal expansion (ZTE).

6. An oscillator as claimed in any one of the preceding claims wherein the operating temperature range in which controlled thermal expansion is maintained is from -200°C to +150°C.

7. An oscillator as claimed in claim 6 wherein the operating temperature range in which controlled thermal expansion is maintained is from -55°C to +125°C.

8. An oscillator as claimed in any one of the preceding claims wherein the material is formed from a crystalline material comprising a plurality of diatomic bridges, each diatomic bridge extending between two atoms in the material, and each diatomic bridge having at least one vibrational mode that causes the two atoms on either side of the bridge to be moved together to the same extent as competing vibrational mode(s) that cause the two atoms on either side of

the bridge to be moved apart.

9. An oscillator as claimed in claim 8 wherein the material comprises a plurality of linear and/or non-linear diatomic bridges.

10. An oscillator as claimed in claim 9 wherein the material comprises linear cyanide - (CN) - bridges and/or non-linear cyanide bridges.

11. An oscillator as claimed in any one of the preceding claims wherein the material is:
$Zn^{II}[Ag^{I}(CN)_2]_2.0.575(AgCM\}$, $Zn^{II}[Au^{I}(CN)_2]_2$, $KCd^{II}[Ag^{I}(CN)_2]_3$, $KMn[Ag^{I}(CN)_2]_3$ or $KCd^{II}[Au^{I}(CN)_2]_3$.

12. An oscillator as claimed in any one of the preceding claims wherein the thermal expansion characteristic of the material is modified by one or more of:

- selective doping of any metal sites present in the material;
- modification of guest molecules in the material;
- modification of counter-ions in the material; and/or
- by altering the degree of interpenetration of material topology.

13. A crystal for an oscillator substantially as herein described with reference to the Examples and/or the accompanying drawings.

14. The use of a material in a crystal-controlled oscillator, characterised in that the thermal expansion characteristic of the material itself enables temperature dependence of the oscillator frequency to be controlled over an operating temperature range for the oscillator.

15. The use as claimed in claim 14 that is use of the oscillator in a timing device.

16. A method of fabricating a crystal for an oscillator from a piezoelectric material having a thermal expansion characteristic that enables temperature dependence of the oscillator frequency to be controlled over its operating temperature range, the method comprising the step of cutting the material in a manner that imparts to an oscillator formed therefrom a near zero, negligible or simple frequency dependence over its operating temperature range.

17. A method as claimed in claim 16 wherein the piezoelectric material is formed to have a zero or near zero thermal expansion characteristic along at least one axis therethrough.

18. A method as claimed in claim 16 or 17 wherein a crystal of the piezoelectric material is grown by slow diffusion at ambient temperature or by solvothermal synthesis at temperatures higher than ambient.

19. A method as claimed in any one of claims 16 to 18 wherein, during formation of the piezoelectric material, the thermal expansion characteristic of the material is modified by selective doping of metal sites, modification of guest molecules, modification of counter-ions, and/or by altering the degree of interpenetration of material topology.

20. A method as claimed in any one of claims 16 to 19 wherein, after formation of the piezoelectric material into a crystal, the thermal expansion properties of the crystal are optimised by cutting the crystal along a direction in which the material has a zero thermal expansion (ZTE) characteristic, or a characteristic closely approaching ZTE.

21. A method as claimed in any one of claims 16 to 20 wherein the crystal forms part of an oscillator as defined in any one of claims 3 to 12.

22. A method of fabricating a crystal substantially as herein described with reference to the Examples and/or the accompanying drawings.